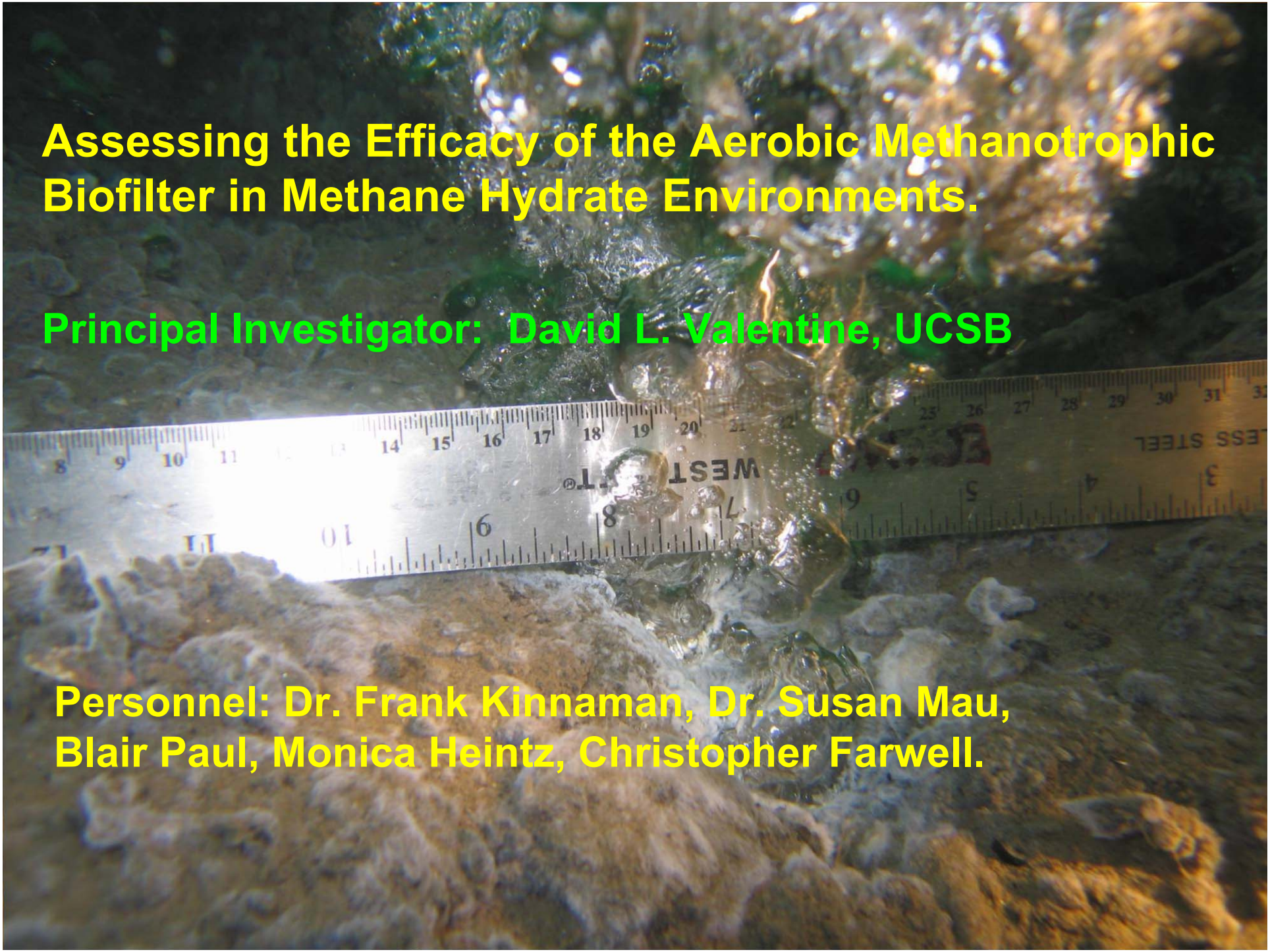


Assessing the Efficacy of the Aerobic Methanotrophic Biofilter in Methane Hydrate Environments.

Principal Investigator: David L. Valentine, UCSB

Personnel: Dr. Frank Kinnaman, Dr. Susan Mau, Blair Paul, Monica Heintz, Christopher Farwell.

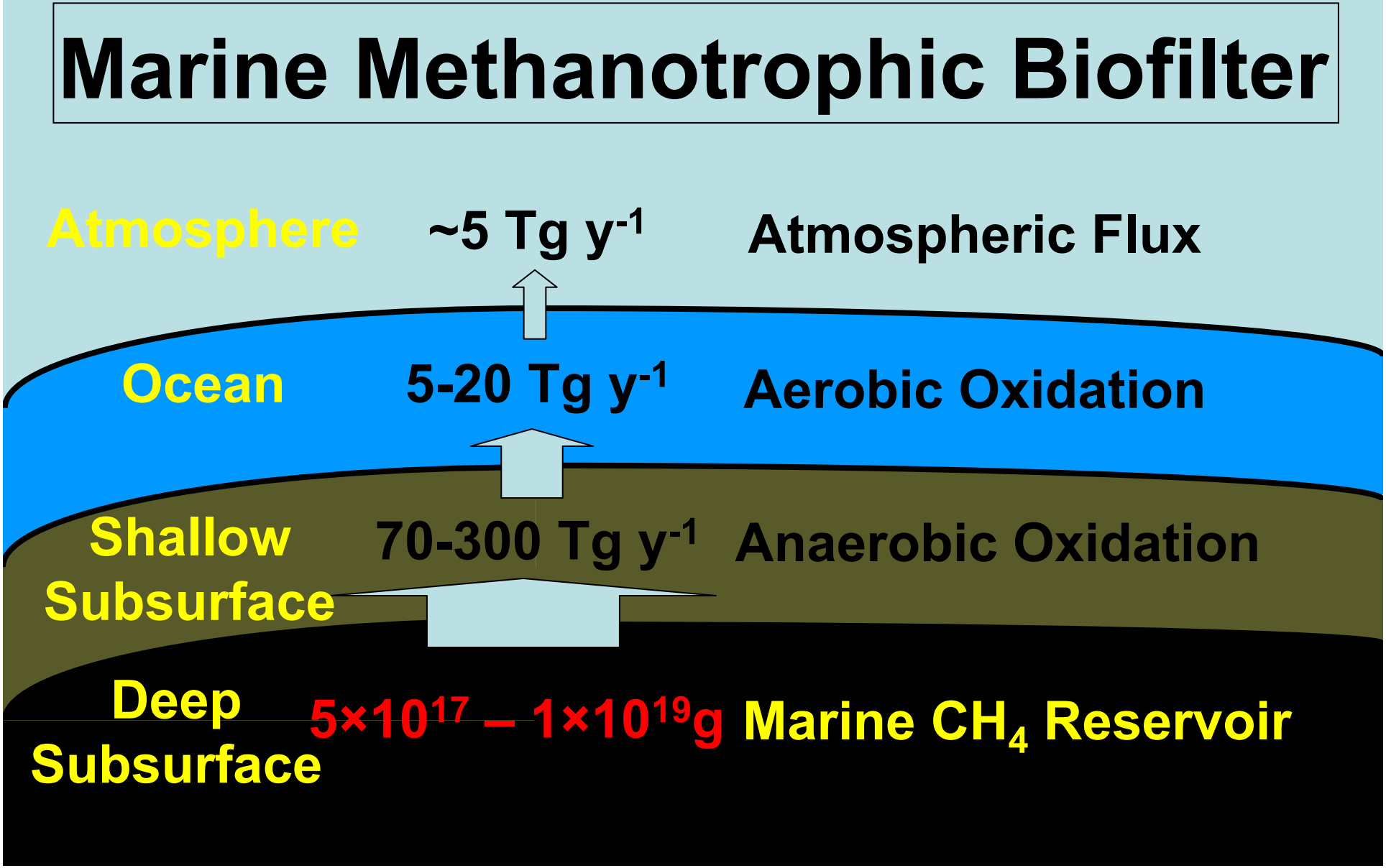
Overarching Goal

- Assess the importance of methanotrophy in preventing the escape of marine methane from hydrate and related reservoirs to the atmosphere.

Outline

- Background
- Objective 1: Impact of mats on flux
- Objective 2: Regional SBB CH_4 budget
- Objective 3: Methanotrophic controls
- Schedule
- Milestones

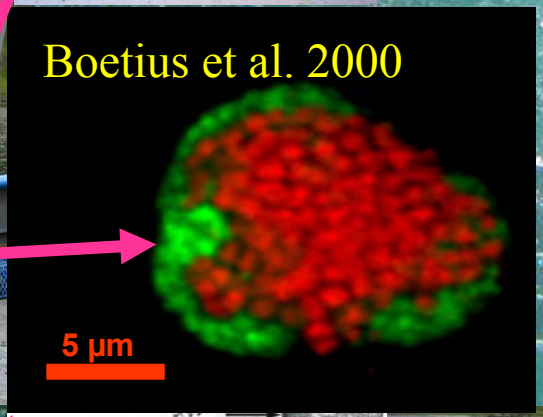
Marine Methanotrophic Biofilter

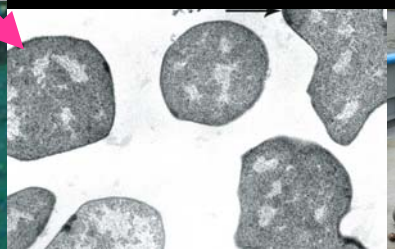


Two Biofiltration Regimes

Anaerobic

$$CH_4 + SO_4^{2-} \longrightarrow HCO_3^- + HS^- + H_2O$$

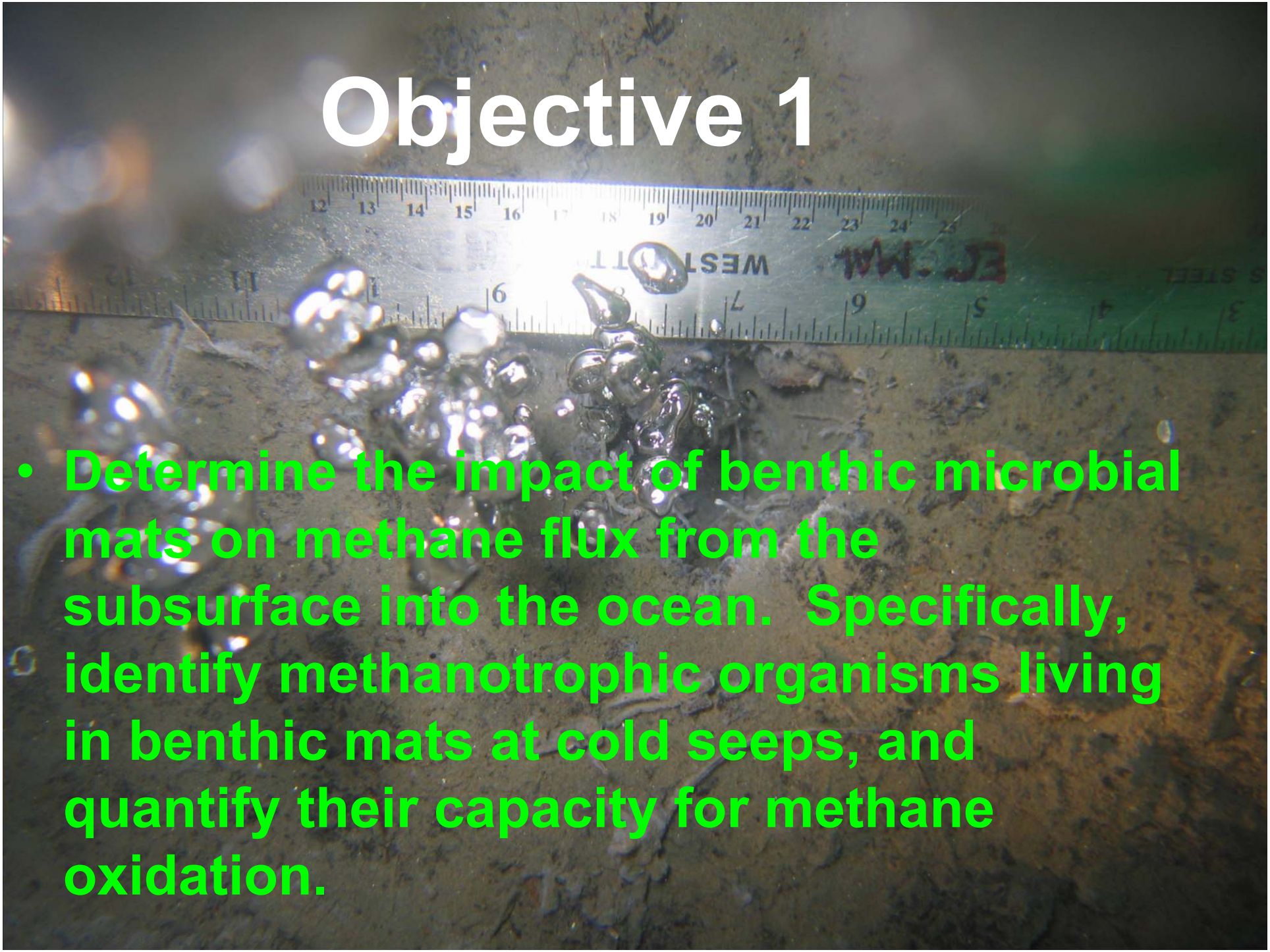




Aerobic

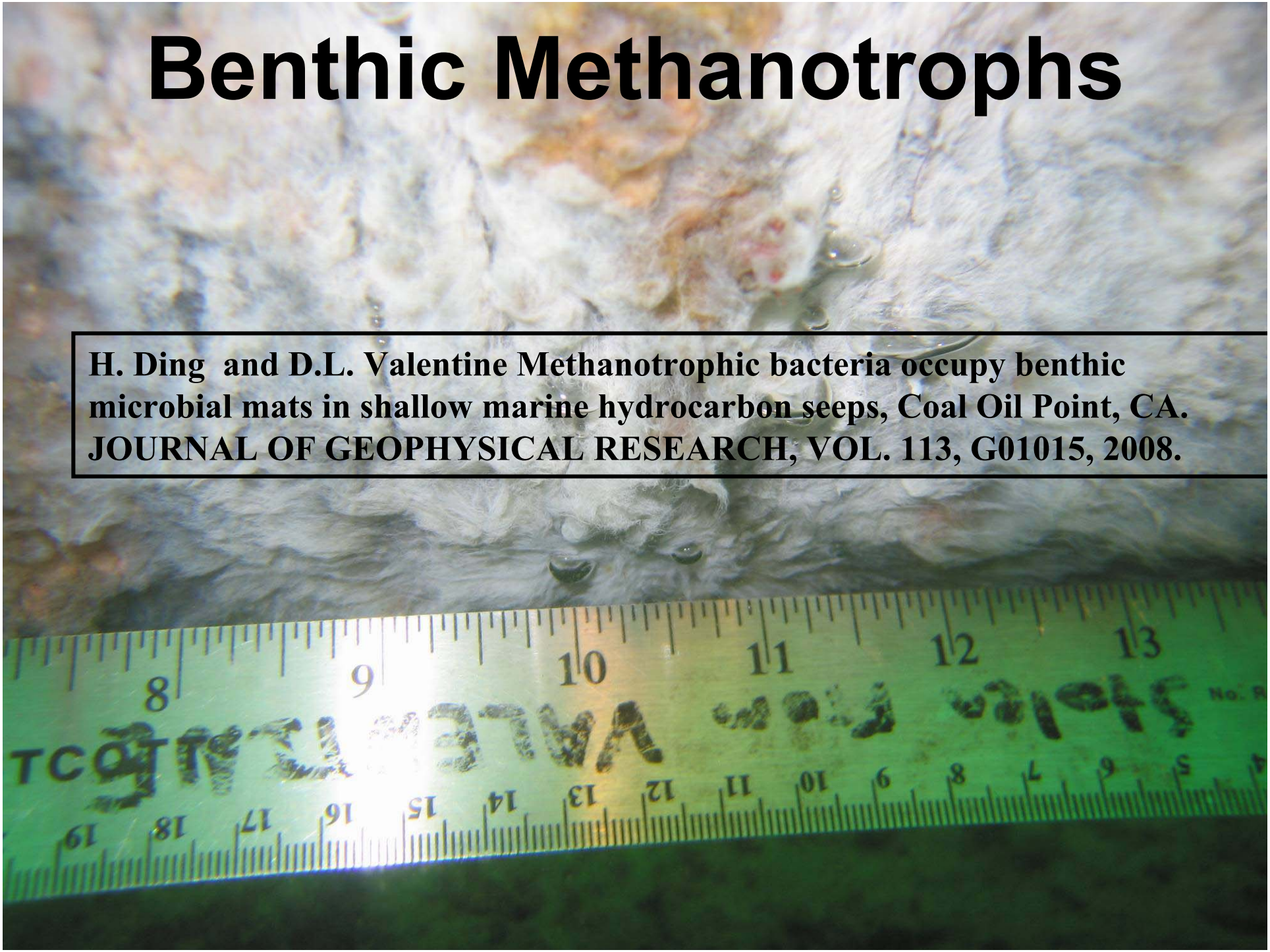
$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

Objective 1



- Determine the impact of benthic microbial mats on methane flux from the subsurface into the ocean. Specifically, identify methanotrophic organisms living in benthic mats at cold seeps, and quantify their capacity for methane oxidation.

Benthic Methanotrophs



H. Ding and D.L. Valentine Methanotrophic bacteria occupy benthic microbial mats in shallow marine hydrocarbon seeps, Coal Oil Point, CA. JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 113, G01015, 2008.


Methanotrophs Rule
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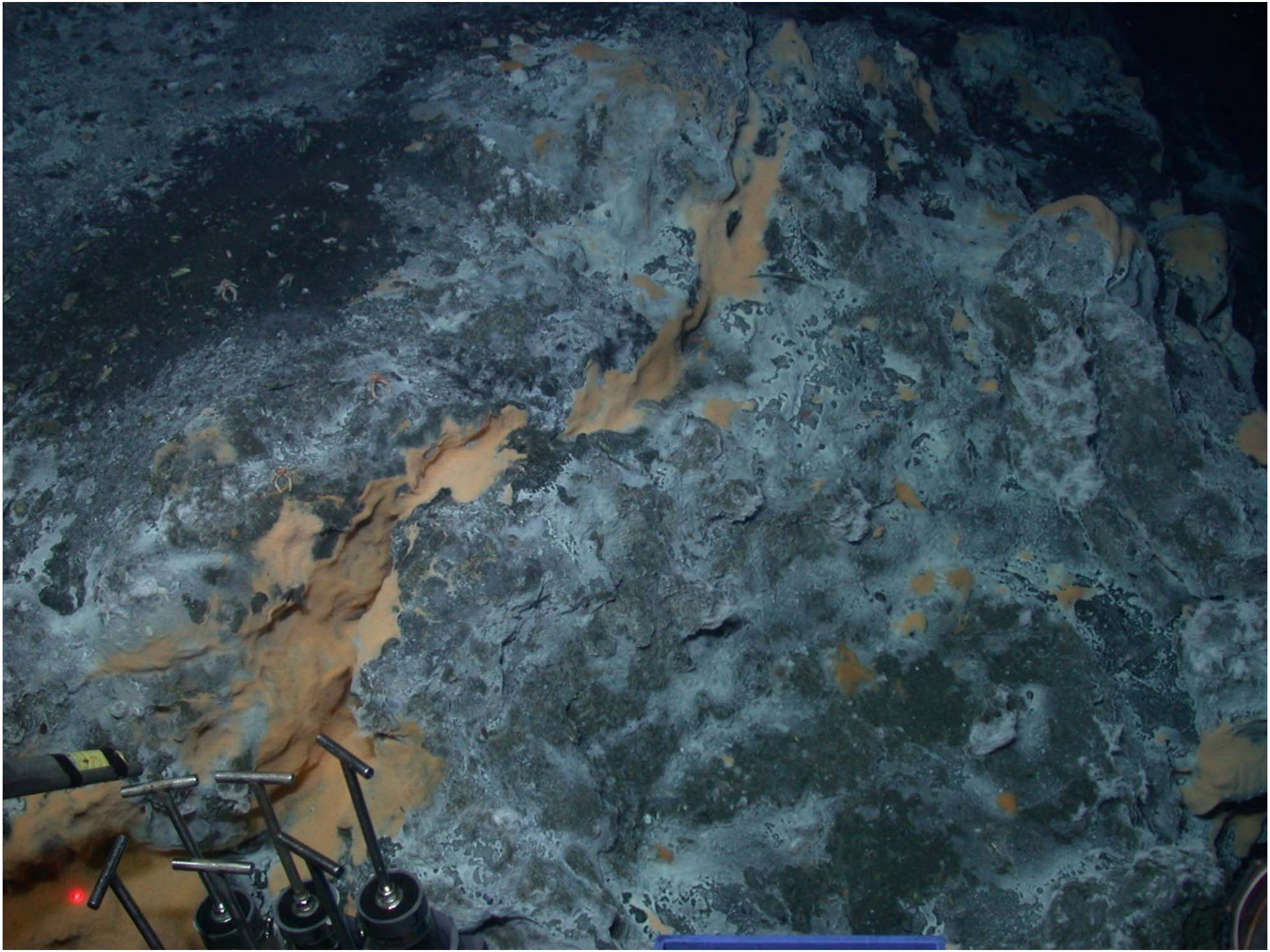
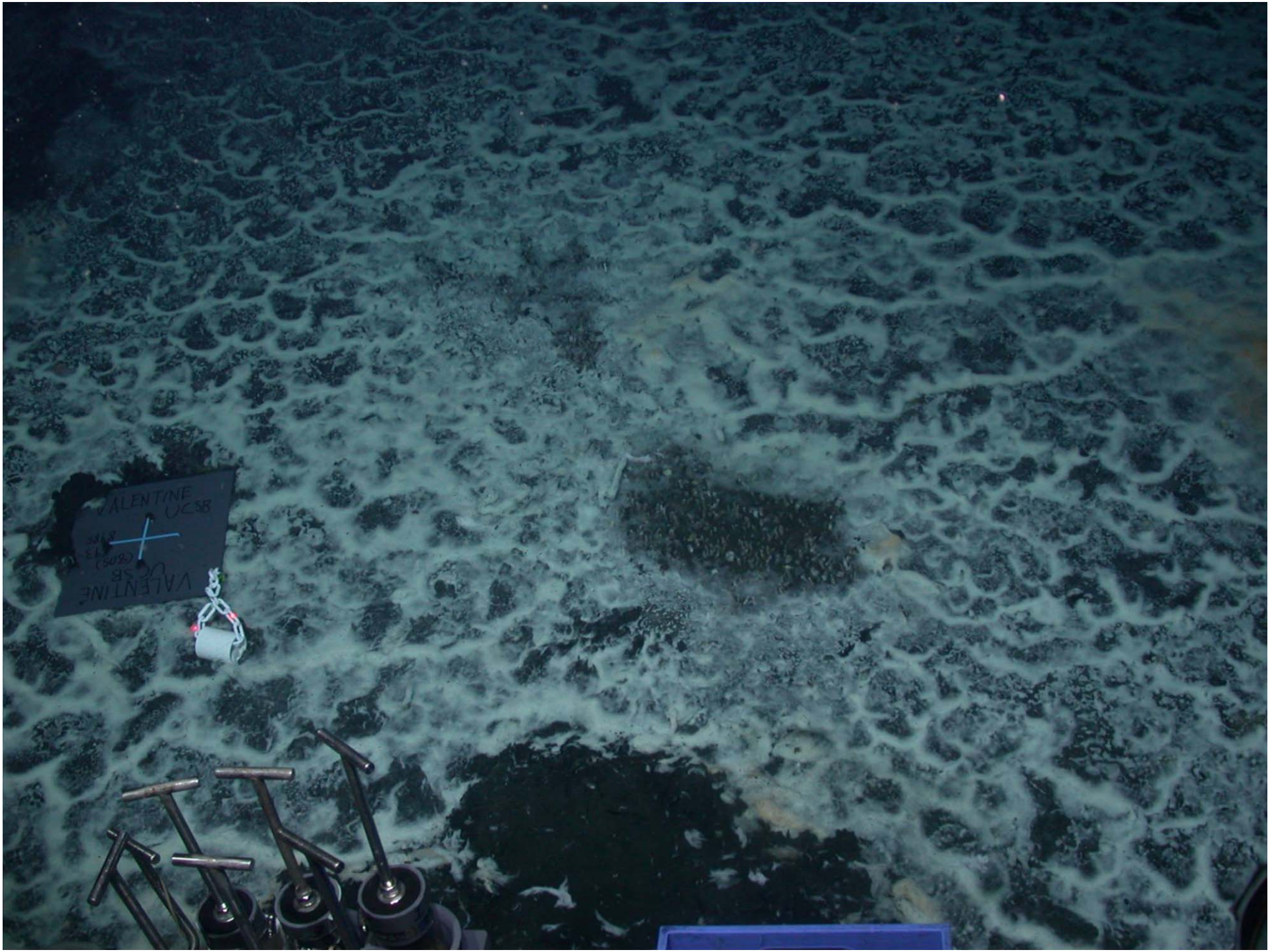
UCSB
VALENTINE LAB, Earth Sciences UCSB
805
→Santa Monica Basin

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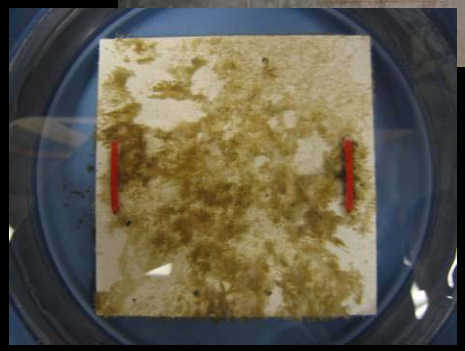
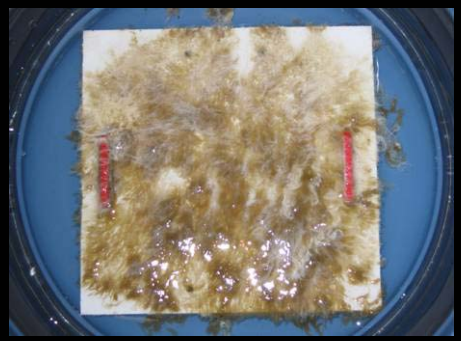
In-situ Cultivation

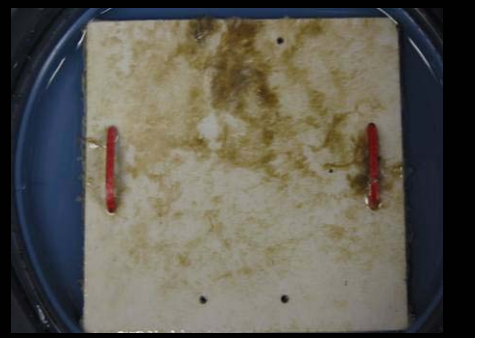


Day 14

Day 21

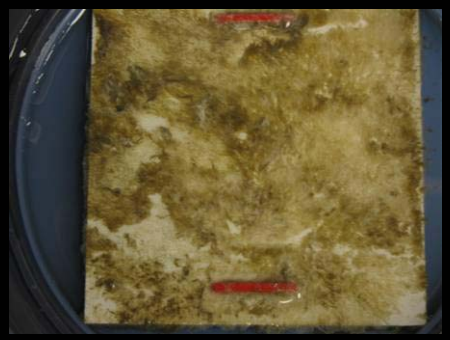


Day 28



Day 35

Day 49



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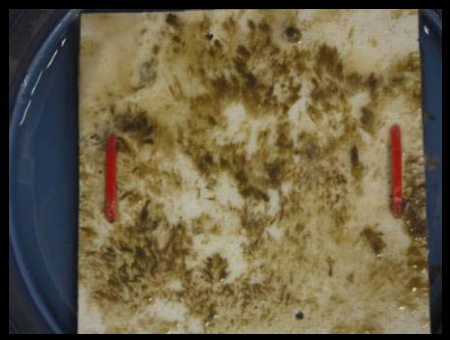
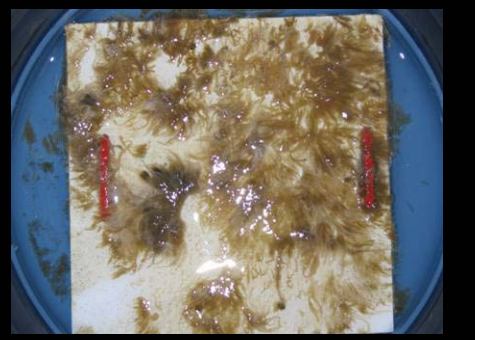


Day 70



Day 77

Day 84

Day 91

Day 98

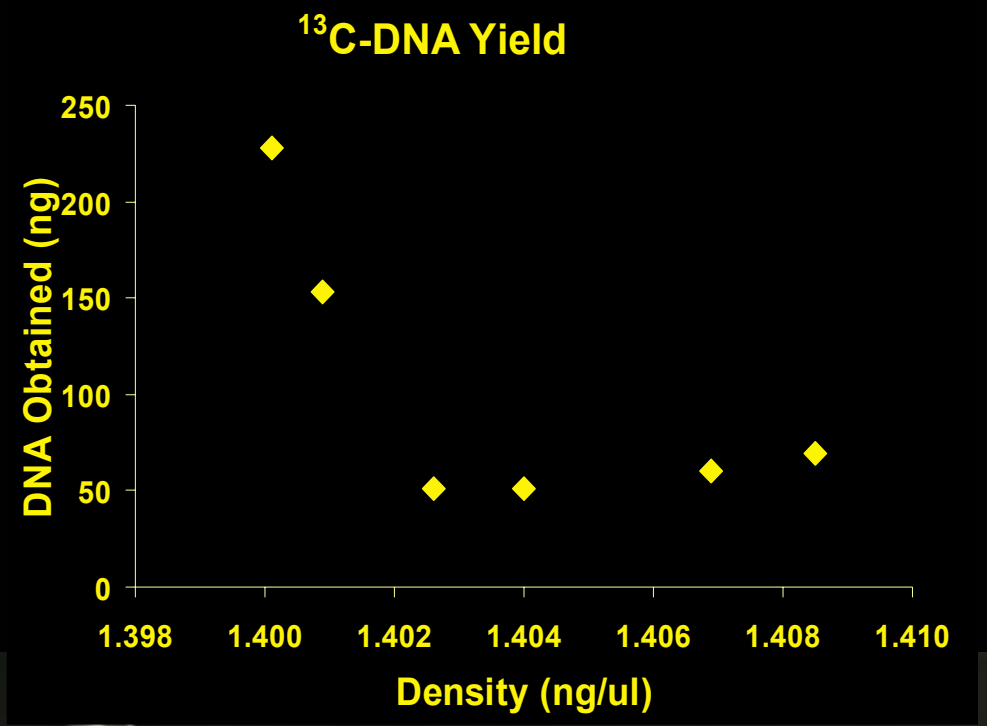
Day 105

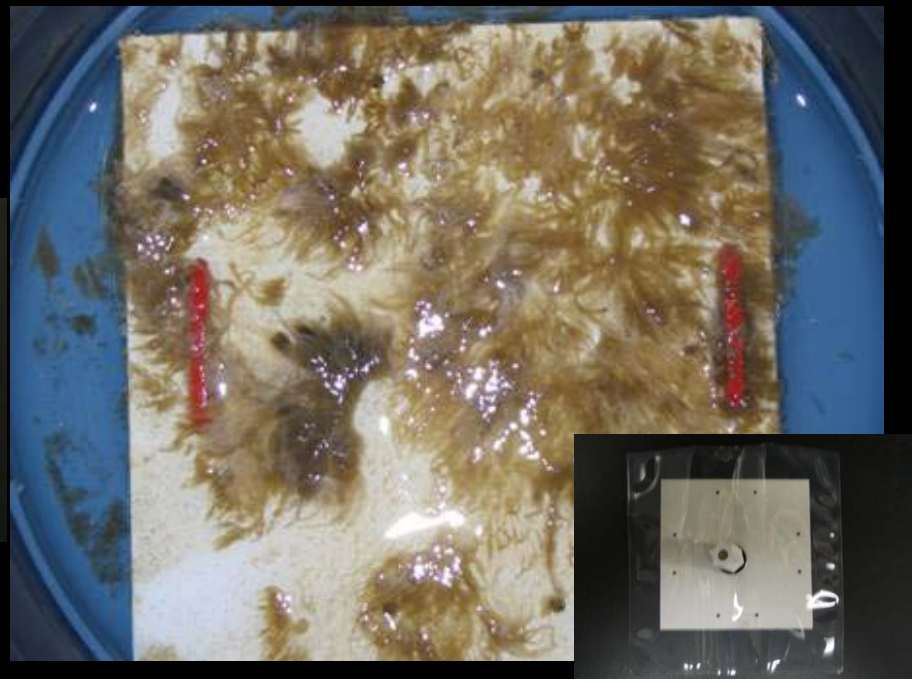
In-situ Incubations

Proposed Experiments

- Molecular analysis of mat communities,
- Rate measurements to assess capacity to oxidize CH_4,
- Isotope probing experiments to directly assess the cellular uptake of CH_4.

Early Results





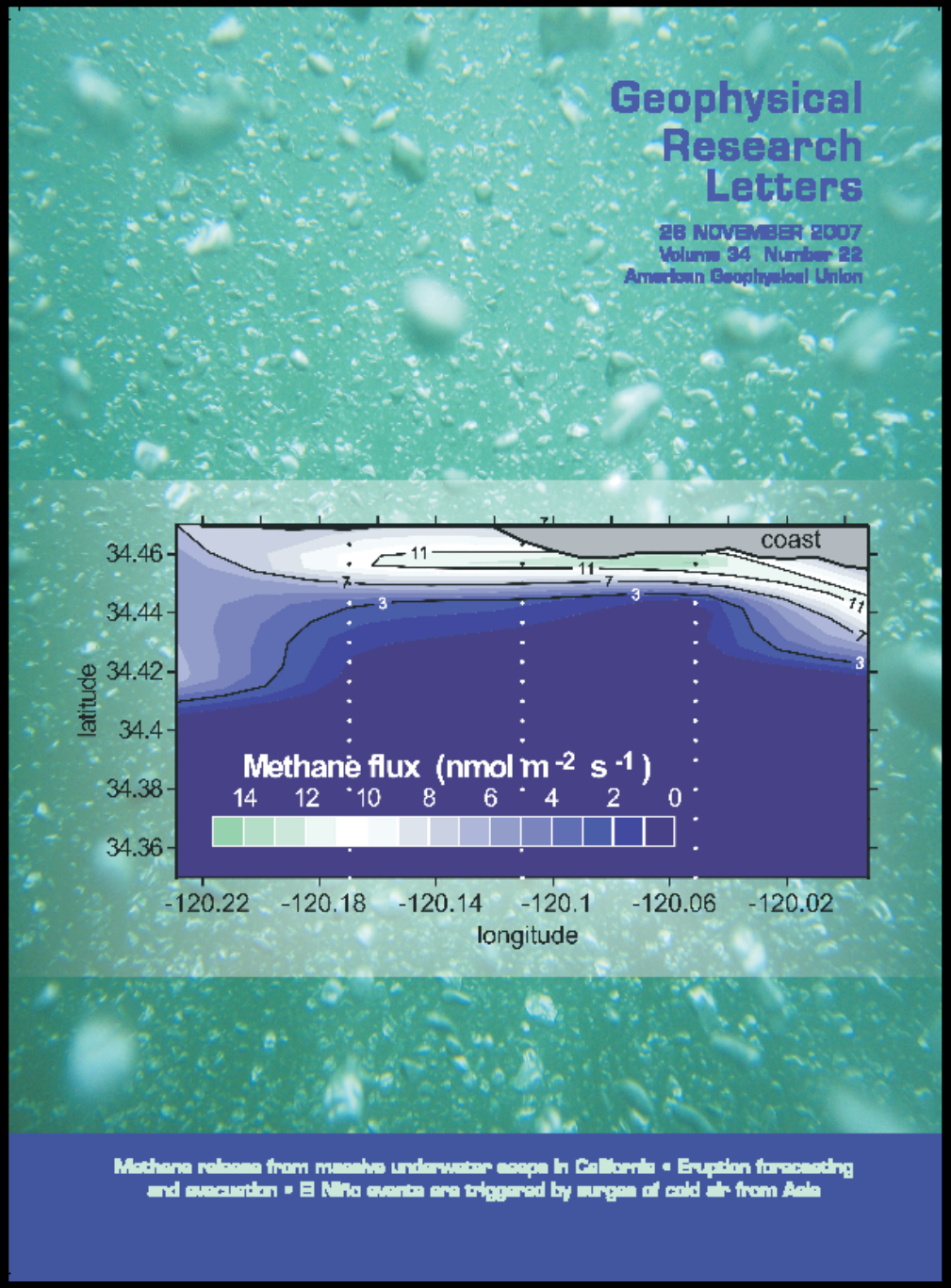
Potential Impact

- **Potential to reveal the identities and importance of benthic communities in moderating the flux of methane from the subsurface to the ocean.**

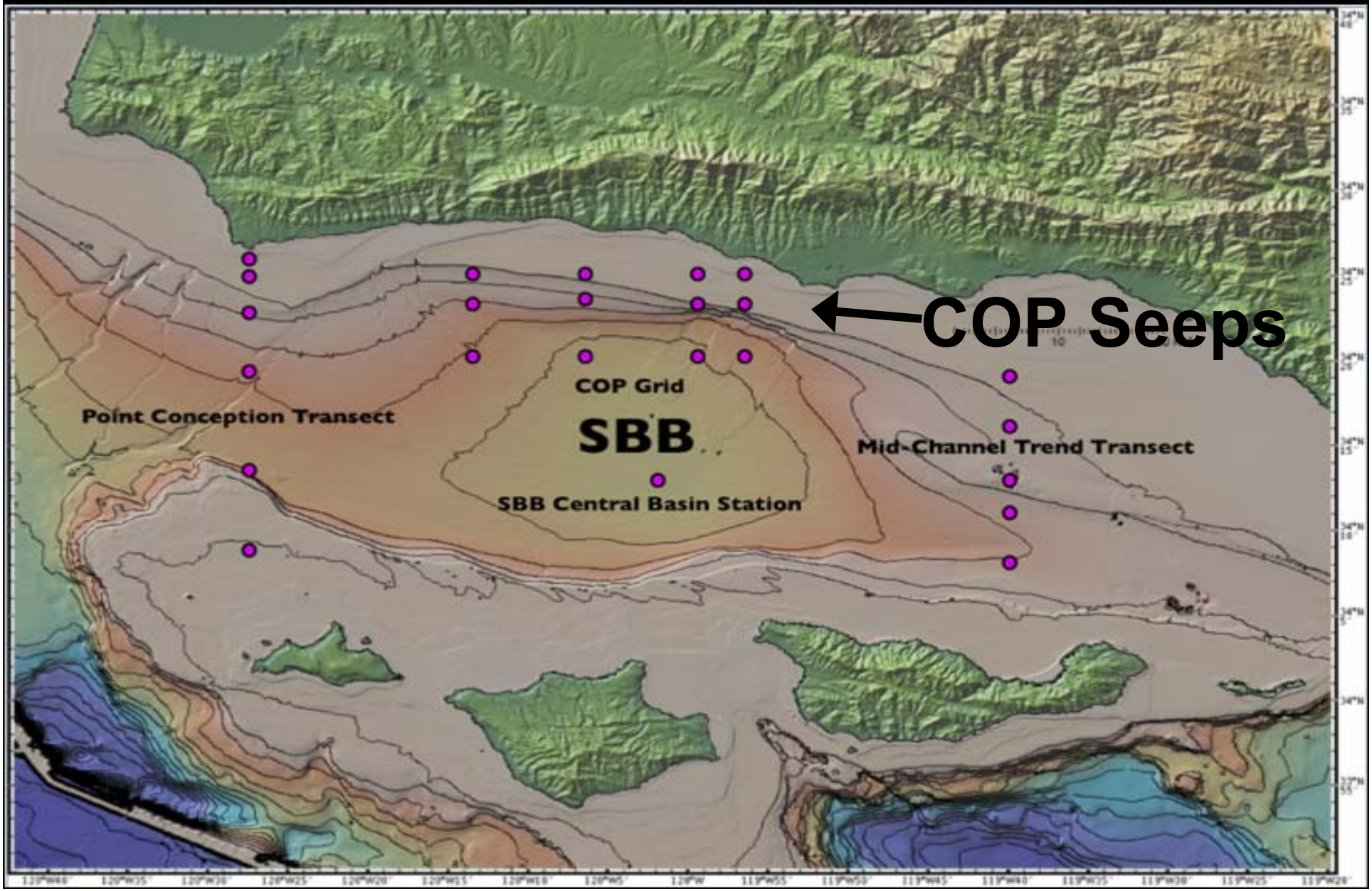
Objective 2

- **Develop a regional methane budget for a classic marine environment containing methane hydrates and cold seeps – the Santa Barbara Basin.**

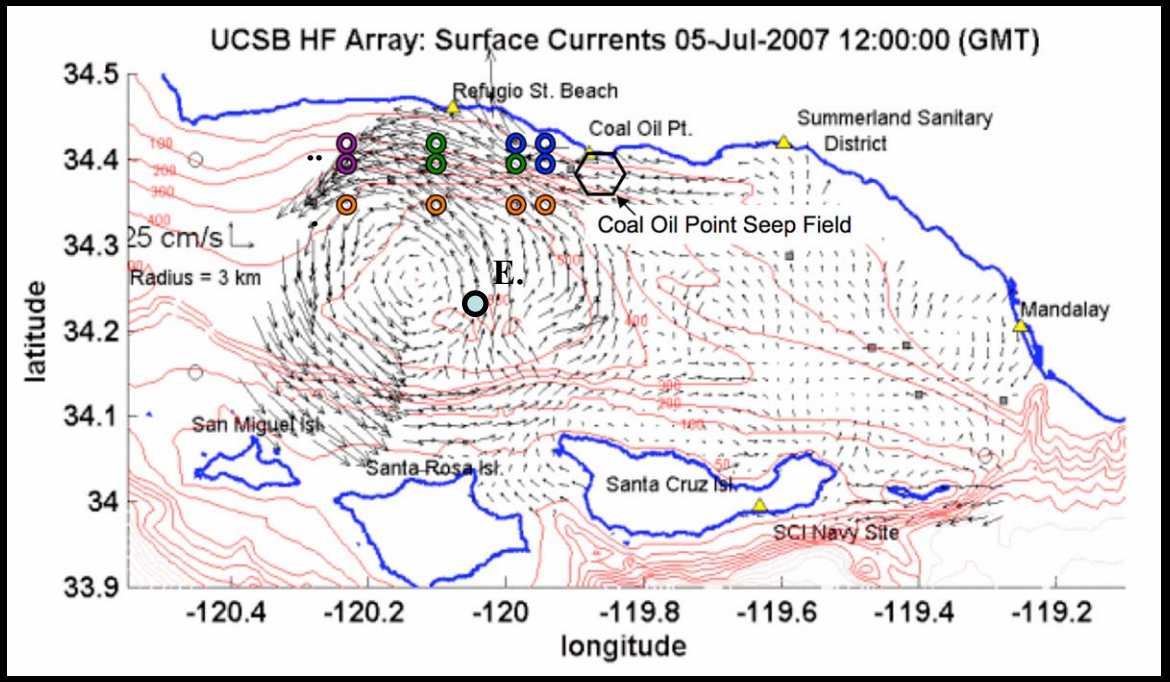
Surface Waters



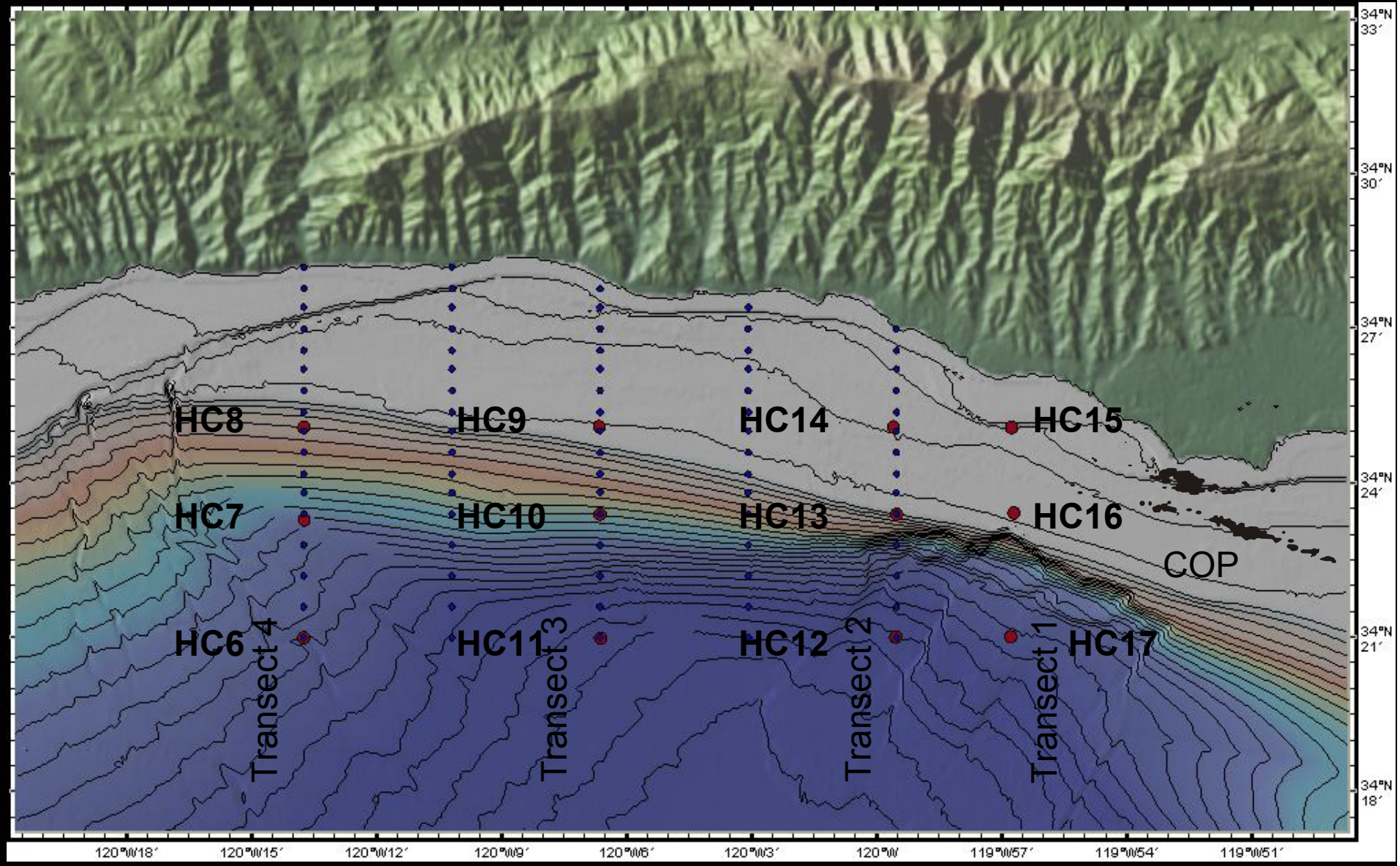
Santa Barbara Basin CH_4 Budget



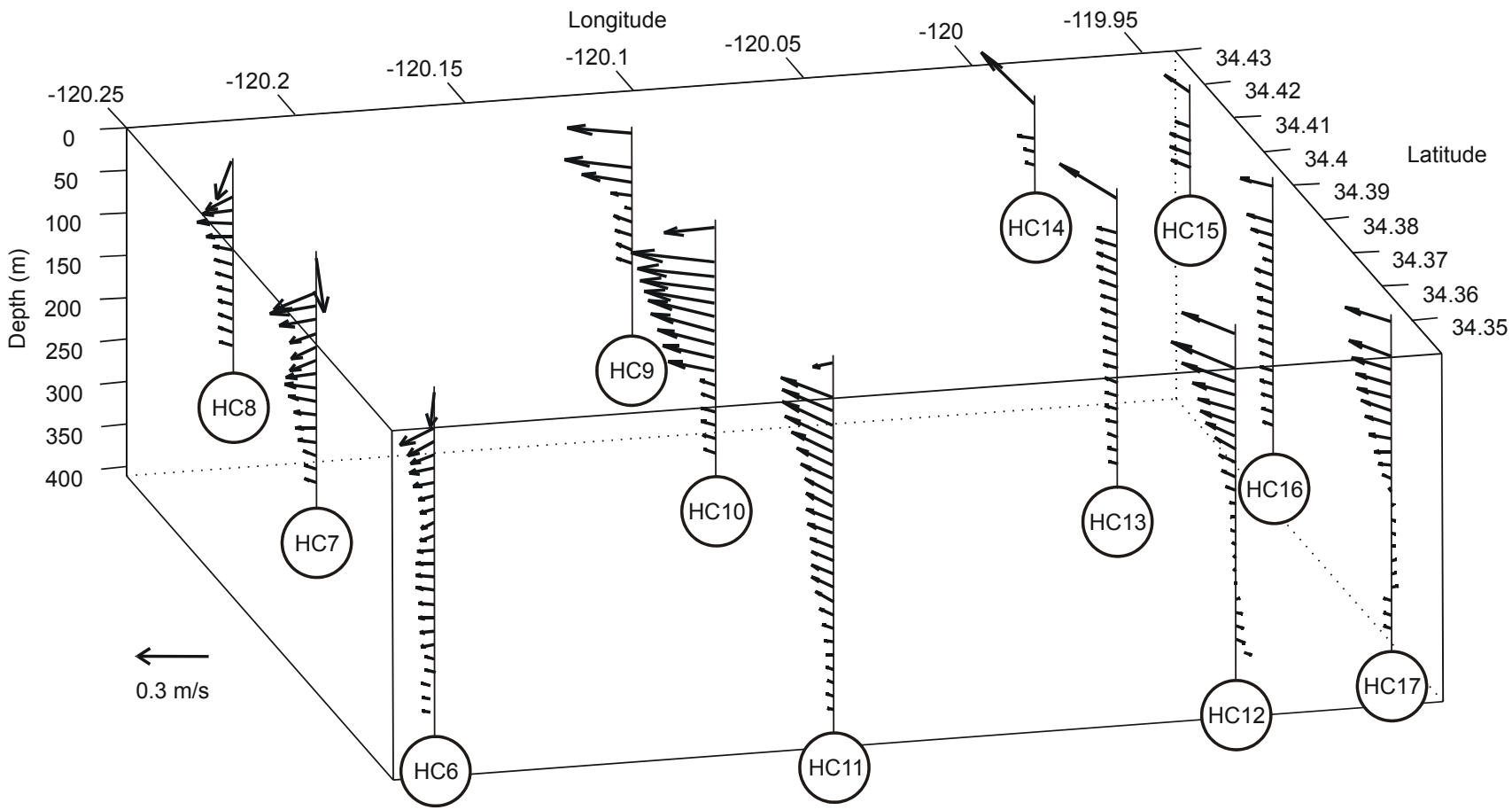
Santa Barbara Basin



Preliminary Budget: COP Plume



Preliminary Budget: COP Plume



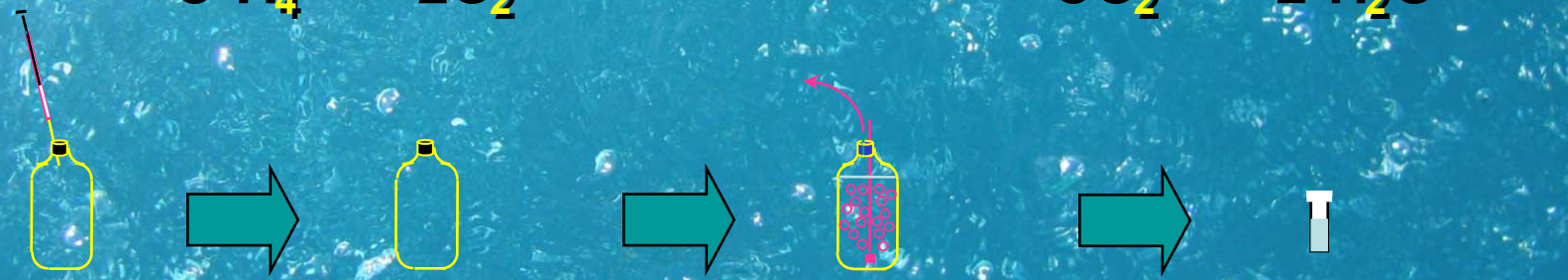
Current Velocity Distributions

Water Column

Experimental Approach:

Methane Oxidation Rate Measurements

$$C^{*}H_4 + 2O_2 \xrightarrow{\textit{Methanotrophs}} CO_2 + 2\,{}^{*}H_2O$$



Inject tracer

Incubate

Sparge unreacted methane

Count radioactivity in the sample

Oxidation rate = Concentration × Fraction oxidized

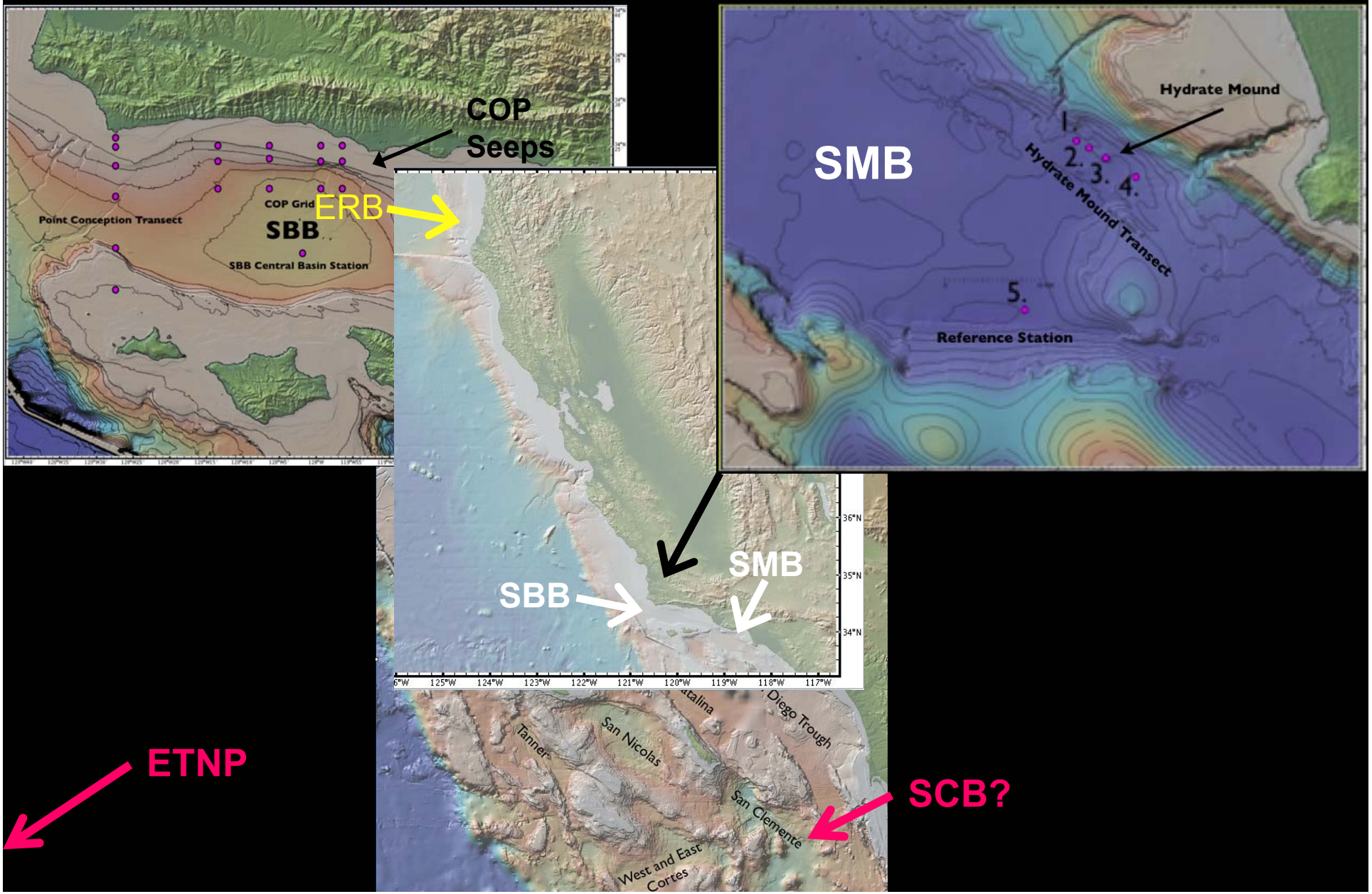
Potential Impact

- **A closed methane budget for the SBB will provide a critical case study on the efficiency of the methanotrophic biofilter for preventing methane release to the atmosphere.**

Objective 3

- **Determine the primary controls on aerobic methane oxidation in marine waters overlying environments with methane hydrates and cold seeps.**

Study Sites


COP
Seeps
COP Grid
Point Conception Transect
SBB
SBB Central Basin Station
ERB
SMB
Hydrate Mound
1.
2.
3.
4.
Hydrate Mound Transect
5.
Reference Station
SBB
SMB
36°N
35°N
34°N
6°W
125°W
124°W
123°W
122°W
121°W
120°W
119°W
118°W
117°W
Tanner
San Nicolas
San Clemente
Diego Trough
West and East
Cortes
ETNP
SCB?

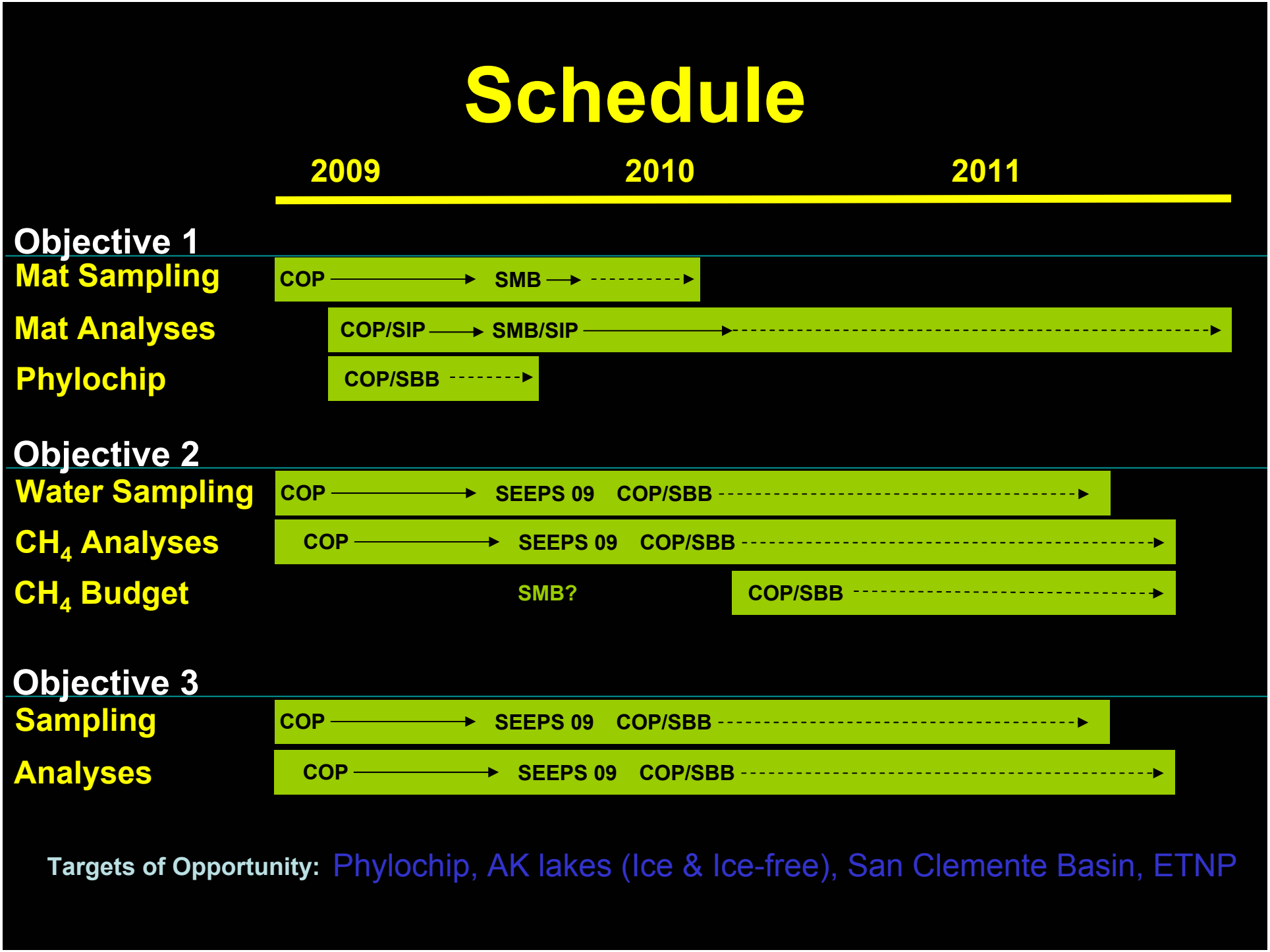
Proposed Experiments

- Methane Concentrations
- Methane Oxidation Rates
- Compare against:
  - Depth, Oxygen, Illumination, Water mass history, Circulation, Basin restriction, Proximity to shore, and other Environmental factors.

Potential Impact

- **Quantitative relationships between environmental conditions and methane turnover can be used to predict the potential of marine methane to escape into the atmosphere, and will feed important parameters into carbon cycle models**

Schedule



Targets of Opportunity: Phylochip, AK lakes (Ice & Ice-free), San Clemente Basin, ETNP

Milestones

- **Milestone 1: Successful installation and sea trial of the CTD rosette system and ADCP. 4/1/09.**
- **Milestone 2: Confirmation of ^{3}H-CH_4 oxidation and ^{13}C-CH_4 uptake by benthic microbial mats from Coal Oil Point seeps. 7/1/09.**
- **Milestone 3: Completion of the SEEPS 09 cruise. Estimated completion date for this milestone is 1/1/10, but the timing will necessarily depend on the UNOLS scheduling. Currently scheduled Aug 27 – Sep 15, 2009.**
- **Milestone 4: Conduct a preliminary analysis for mmo and 16SrRNA gene sequences for putative methanotrophs from the Santa Monica Basin, and compare to sequences from Coal Oil Point seeps. 7/1/10.**
- **Milestone 5: Complete a preliminary analysis of current velocity data and oxidation rate data from the SEEPS 09 cruise. 10/1/10.**
- **Milestone 6: Complete the ocean-going sampling program, and perform preliminary analysis of all physical and chemical data to ensure sufficient data for further analysis. 4/1/11.**